WHITMAN. (R)

OBSERVATIONS

ON

Forty-Five Cases of Flat-Foot,

WITH PARTICULAR REFERENCE TO

ETIOLOGY AND TREATMENT.

By ROYAL WHITMAN, M.D.,

Surgeon to the Orthopedic Department of the Boston Dispensary.

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OBSERVATIONS ON FORTY-FIVE CASES OF FLAT-FOOT WITH PARTICULAR REFERENCE TO ETIOLOGY AND TREATMENT.[1]

BY ROYAL WHITMAN, M.D.,
Surgeon to the Orthopedic Department of the Boston Dispensary.

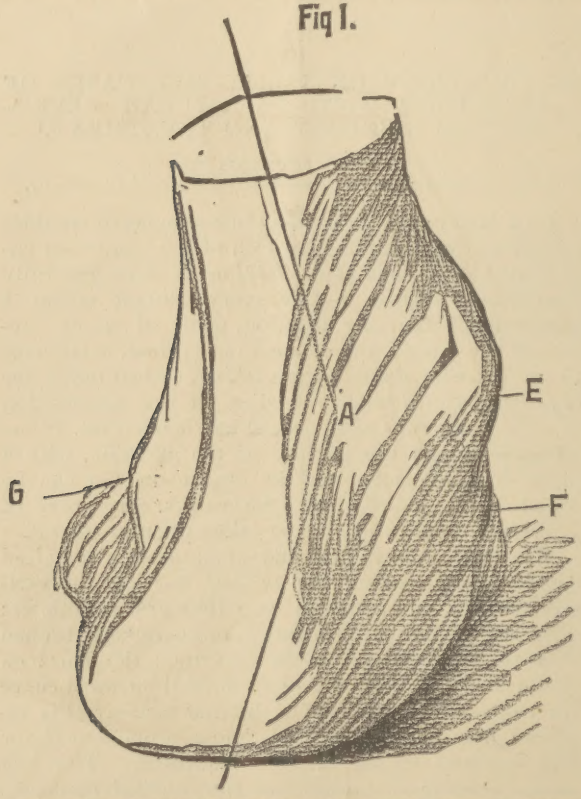
I AM inclined to think that the frequency of troubles caused by overstraining the arch of the foot is not appreciated, and that the condition is not generally recognized, because nearly every patient whom I have treated for this affection, many of whom presented the typical appearances of flat-foot, sometimes to an extreme degree, were taking, or had taken for long periods, internal remedies on the supposition that the symptoms were caused by rheumatism. Some observations on the etiology of the affection, with a more detailed account of its treatment than can be found in surgical or orthopedic works, may prove of interest to those who may be called upon to treat it.

The gross appearances and symptoms in acquired flat-foot have been sufficiently well described by various writers. In a typical case they are as follows: The arch of the foot is lowered; or completely broken down, so that the entire sole rests upon the floor; on the inside of the foot the slight normal outward curve from the heel to the head of the first metatarsal is replaced by a bulging inwards, most prominent below and in front of the internal malleolus. The foot seems broader than usual, and the internal malleolus is abnormally prominent; when the patient stands the entire foot seems displaced outwards on the leg, this being especially marked when looking at it from behind; the tissues on the inside of the arch and ankle

[1] Read at the meeting of the Surgical Section of the Suffolk District Medical Society, April 4, 1888.

seem thickened and congested; prominent veins and increased moisture of the foot are often noticed; in

Fig 1.



Drawn from a cast of the flat-foot, showing the outward displacement of the foot on the leg.

A, the weight-bearing centre of the astragalus, which should normally be in the line of traction of the Tendo Achillis; E, internal malleolus; F, head of the astragalus; G, external malleolus.

walking the feet are turned out more than usual, and a short awkward step is sometimes observed (see plates

1 and 2); the subjective symptoms are various, the most constant being pain especially after long standing

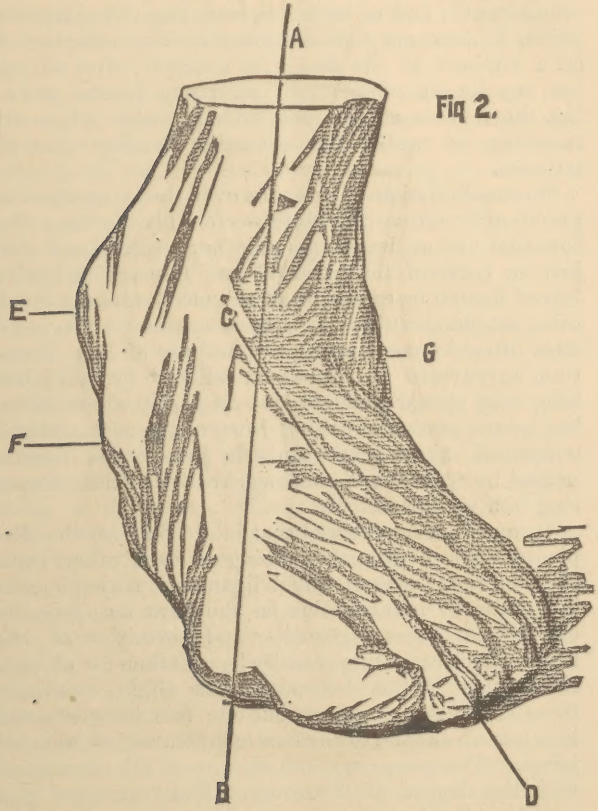


Fig 2.

Anterior view, showing the eversion of the fore-foot. The line A B, drawn through the axis of the leg, should normally fall through A, C, D.
E, internal malleolus; F, head of the astragalus; G, external malleolus.

or walking, most often about the inside of the ankle, sometimes shooting up the inside of the leg, or in the

outside of the ankle, the ball of the foot, the heel, or middle of the sole; as patients express it, the foot seems heavy, and to have lost its spring; a symptom which I have not seen described is often complained of, a stiffness in the foot; for example, after sitting for any length of time, or on rising in the morning, the feet seem stiff and unmanageable when attempting to walk, the sensation lasting several minutes.

On manipulation — pressure over the astragalo-scaphoid articulation is painful — forcibly turning the fore-foot out or in, causes pain here, sometimes also just in front of the external and internal malleoli; forced flexion or extension of the medio-tarsal joint is often attended with pain. These symptoms may, and most often do, come on slowly, and are of long duration, aggravated by overwork, relieved by rest; but they may appear suddenly, as in cases where there has been a gradual breaking down of the arch, a slight unnoticed injury may result in great pain, accompanied by redness and swelling; really, a sprain occurring in a weakened foot.

It must be remembered that in old flat feet the displaced bones constantly rubbing on each other, pressing on their overstretched ligaments, may induce a low grade of inflammation, as shown at autopsies by eroded cartilages, ligaments and porosities of the bones. Such cases might easily be mistaken for chronic rheumatism, if the deformity were slight, especially if, as sometimes happens, but one foot were affected in a person subject to rheumatic inflammation in other joints. The symptoms, too, do not at all correspond with the degree of deformity. Many persons with complete flat-foot have no trouble, while others who are practically disabled by it show but a slight flattening of the arch.

Many flat feet can, by manipulation, be nearly or quite replaced in their normal position, others only partially.

In order to understand the etiology of the affection, and that the reasons for the treatment which will be recommended may be made clear, it will be necessary to describe some of the anatomical peculiarities of the foot.

The astragalus, when the foot rests upon the ground, is usually held firmly between the tibia and fibula, permitting almost no movement except as a hinge-joint, the lateral movements taking place in the joint btween it and the os calcis, to which it is attached principally by the interosseous ligament. When the foot bears weight the tendency is to abduction, that is, a slight flattening out of the arch, a turning out of the toes, and a tilting of the os calcis over towards the inner side, its anterior extremity turning slightly inwards and downwards, while the point of the heel turns slightly outwards.

There is a slight rotation of the astragalus forwards, downwards, and inwards, so that its anterior extremity, or head, articulating with the scaphoid, becomes more prominent: also a broadening and slight lengthening of the foot. These movements, which normally take place to an appreciable extent, are exaggerated in a foot whose muscles are weakened and ligaments stretched from overwork; thus the anterior extremity of the os calcis falls inwards and downwards, the bone tilts over so that its external tubercle is raised to a considerable angle with the floor. This change would affect the level of the astragalus in its relation to the leg bones, were it not for the fact that its increased rotation allows its outer margin to sink down into the interosseous fossa, pressing before it the interosseous ligament, a movement which depresses its external and raises its internal border. The head of the astragalus, in its exaggerated rotation, presses inwards on the internal lateral, and inwards and downwards on the calcaneo-scaphoid ligaments, while its axis which should be in a line with the second toe, may point inside the great toe.

The distance between the internal malleolus and the sustentaculum tali is increased, and the external malleolus comes in close proximity to the os calcis, pressing on the external ligaments. At the same time the flattening and abduction of the foot strain, to a certain extent, all its minor ligaments. After a time the displacement may become permanent. Then may follow changes in muscles, ligaments, cartilages and bones.[2]

In order to ascertain the amount of rotation of the astragalus, and the expansion of the heads of the metatarsals under weight, a series of comparative measurements, of normal and flat feet, in children and adult males and females, were made, with the following results:

A, Length of foot.
B, Distance between the external malleolus and the head of the astragalus, the foot resting easily on the floor at a right angle with the leg.
C, The same measurement when the foot sustains the entire weight of the body.
D, Distance between the head of the first and fifth metatarsals.
E, Same measurement under weight.
Measurement in Millimetres.

CHILDREN.

	Normal.						*Flat.*					
	Age	*A*	*B*	*C*	*D*	*E*		Age	*A*	*B*	*C*	*D*	*E*
1	8	184	54	56	71	75	1	7	184	55	59	62	70
2	10	190	54	59	72	76	2	12	209	57	63	67	76
3	11	190	63	69	79	88	3	8	210	59	61	70	78
4	11	194	62	64	74	78	4	9	215	61	64	76	81
5	12	197	65	69	79	86	5	12	222	61	64	78	85
6	9	200	51	61	72	76	6	13	222	72	75	75	82
7	11	203	57	63	70	73							
8	13	210	61	66	75	82							
9	13	210	62	67	75	82							
10	13	228	62	69	83	86							
Avge.		200.6	59.7	64.3	75	80.2	Avge.		210.3	60.8	64.3	71.3	78.6

[2] Vide Autopsies.
Symington. Journal of Anat. and Phys., Oct., 1884.
Stokes. Annals of Surgery, Oct., 1885.
Humphrey. Lancet, March 20, 1886.
Hueter. Grundriss der Chirurgie, 2 Hälfte, 1882.
Von Meyer. Ursache und Mechanismus der Entstehung des erworbenen Plattfusses, 1883.

WOMEN.

	Age	*Normal.* A	B	C	D	E		Age	*Flat.* A	B	C	D	E
1	36	203	57	61	83	89	1	60	229	70	72	89	99
2	18	209	62	67	89	97	2	45	229	70	76	77	85
3	38	209	61	64	78	89	3	25	235	67	71	91	97
4	38	209	51	62	89	95	4	50	241	69	71	100	113
5	38	209	61	62	84	91	5	24	241	64	69	89	94
6	36	216	76	80	92	105	6	29	254	69	71	99	115
7	20	222	64	69	85	94							
8	50	229	67	73	99	107							
9	30	248	69	70	92	95							
10	34	248	71	75	92	95							
Avge.		220.2	64.4	68.3	88.3	95.7	Avge.		238.1	68.1	71.5	90.8	100.5

MEN.

1	30	235	69	70	92	94	1	28	254	75	81	101	104
2	30	241	69	75	88	94	2	25	261	82	85	105	107
3	35	241	67	70	94	97	3	18	264	81	91	93	94
4	32	244	61	70	91	94	4	50	266	83	87	103	107
5	30	248	69	70	92	95	5	45	267	78	83	99	102
6	28	254	69	71	88	94	6	20	268	83	84	94	102
7	33	257	75	76	92	100	7	18	268	72	78	102	110
8	21	260	78	83	97	105	8	17	268	78	83	95	107
9	33	262	71	76	97	100	9	25	279	80	82	95	101
10	30	262	71	75	95	100	10	40	292	73	76	98	109
Avge.		250.4	69.9	73.6	92.6	97.3	Avge.		268.7	78.5	83	98.5	104.3

RECAPITULATION.

Children.

Length of foot in normal cases 200.6
" " " flat cases 210.3
Distance from external malleolus to head of astragalus, normal 59.7
" " " " " " flat 60.8
Rotation of astragalus in normal cases 4.6
" " " flat cases 3.5
Expansion of head of metatarsals in normal cases . . 5.2
" " " " " " flat cases . . . 7.3

Women.

Length of foot in normal cases 220.2
" " " " flat cases 238.1
Distance from external malleolus to head of astragalus, normal 64.4
" " " " " " flat 68.1
Rotation of astragalus in normal cases 3.9
" " " " flat cases 3.5
Expansion of heads of matatarsals in normal 7.4
" " " " " " flat 9.7

Men.

Length of foot in normal cases 250.4
" " " " flat cases 268.7
Distance from external malleolus to head of astragalus, normal 69.9
" " " " " " " " flat 78.6
Rotation of astragalus in normal cases 3.7
" " " " flat cases 4.5
Expansion of metatarsals in normal cases 4.7
" " " " flat cases 5.8

These measurements would seem to show that the flat-foot is longer than the normal; that the distance between the external malleolus and the head of the astragalus is greater, showing a certain amount of permanent rotation and displacement of this bone; that the fore-foot in flat cases is broader, and the expansion of the metatarsals is greater than in normal cases.

The area of rotation of the astragalus in women and children was restricted in the flat cases, because of the certain amount of permanent rotation which already existed, while in men it was increased. This variation may be explained by the fact that there are two classes of flat-foot, the most exaggerated types being met with in men, as might be expected, from their more laborious occupations.

(1) In well-marked cases, characterized by extreme laxity of ligaments, with very great deformity, as shown in Figures 1 and 2. Yet the symptoms are usually slight, and often no discomfort, other than the very apparent deformity, is experienced. The foot in young subjects can by manipulation be almost entirely replaced to its normal shape. In this class, the area of rotation of the astragalus is increased. As an example, Case No. 3 of the flat feet in men may be cited. Here measurement b. is 81 mm., compared with a normal of 69.9, the rotation of the astragalus 10 mm., compared with a normal of 3.7. The fore-foot in this case was so everted as to be almost useless in walking, the waist of the foot under weight measuring 91 mm., and the heads of the metatarsals 94 mm., compared with the normal of 73.6 and 97.3. Lesser grades of this type are usually classed as weak ankles.

(2) The cloddy type, characterized by flatness of the sole, with much less deformity. The foot seems thick and unyielding. The shape can be but slightly changed by manipulation. The pain is often severe, with tenderness of the joint on pressure and conges-

tion of the foot. In this class, the rotation of the astragalus is restricted. It may be that the greater severity of symptoms in this class is due to more unyielding ligaments, which, allowing a certain amount of displacement, then hold the bones closely against each other in their abnormal positions, so that the effect of pressure in inflammation and other changes may be more apparent.

The early recognition of the affection is of considerable importance to the future comfort of the patient, and it may be stated that pain in the feet, aggravated by standing or walking, with pain on pressure over the astragalo-scaphoid joint, or pain on motion at the medio-tarsal joint, are symptoms much more likely to be caused by an over-strained arch, even though no deformity exists, than by ill-fitting boots or subacute rheumatism, and that "sprained ankles" are often in reality sprained feet.

As to the etiology of acquired flat-foot, various theories have been advanced.

THE MUSCULAR THEORY.

(1) Paralysis or atrophy of the tibialis anticus.[3]

(2) Paralysis of the peroneus longus.[4]

It is interesting to note that Sayre, finding in his cases the changes in the tibialis anticus, did not discover the affection of the peroneus longus, while Duchenne not only found no weakening of the tibialis anticus but says: "I have demonstrated that every flat-foot of which the etiology or genesis is in muscular action, is produced by preponderance of the tonic force of the tibialis anticus, which, as will later be demonstrated, destroys the plantar arch" (p. 457).

Mr. Golding-Bird, in fifty cases of flat foot, found no atrophy or paralysis of the tibialis anticus.[5]

In the forty-five cases examined by me, no paralysis was found, or muscular changes that might not better

[3] Sayre. Orthopedic Surgery, p. 62.
[4] Duchenne. Physiologie des Movements.
[5] Guy's Hosp. Reports, Vol. xli, 1883.

be classed as results than causes; for example, in some cases where there is a considerable displacement of the astragalus to the inside, as in Figure 1, it is difficult or impossible for the patient to flex the foot in an adducted position, as is the ordinary action of the tibialis anticus; this might be thought due to atrophy of that muscle, but it may be more easily explained by this displacement of the astragalus, which necessitates a wide movement of the fore-foot about its head: if the displacement be so great as to render this impossible, the foot must be flexed and abducted as though it were moved by the long extensor of the toes. I have noticed, too, in some of these cases, when attempting manually to flex and abduct the foot, that there seemed to be an abnormal resistance in the calf muscle, which had been acting so long with its tendon displaced outwardly in its relation to the foot.

LAX LIGAMENTS.

By some, flat-foot has been ascribed to lax ligaments. As to this, it may be said that some persons have strong muscles, and others weak ones. So, too, there is a great difference in ligaments. One has only to examine a certain number of normal joints to convince himself of this. It seems reasonable that a person whose muscles are weak and whose joints are loose, will, under favoring conditions, develop flat-foot, while another with strong muscles and closer joints would not. It does not follow, however, that a primary relaxation of ligaments is the ordinary cause of this affection. It is impossible to say how much hereditary influences have to do with the causation of flat-foot. No. 1, of "flat feet in men," a case of extreme deformity, informed me that he was one of eight brothers, all of whom had feet as flat as his own. No. 3, already cited, the most extreme case of all, said he had inherited the affection from his father, yet he had three brothers with perfect feet. The occupation, in which he had been engaged for five years,

bell-boy in a hotel, a most trying one for the feet, may have been in his case a more important factor than inheritance.

I am not now speaking of the negro type of foot, long, flat, with projecting heels, but of cases that would be considered typical illustrations of the deformity. In one family I found three generations of flat feet. The child, however, showed marked evidence of rachitis, an affection in which it is usually present.

HIGH HEELS.

Mayo-Collier[6] contends that the wearing of high heels is the cause of flat feet, quoting Little: "a slight degree of atonic valgus is common in girls, especially in those of the upper and middle classes." "Why not in the less fortunate and badly-nourished females of the lower classes? Because the high heels are less prevalent with them." My experience leads me to consider "atonic" flat-foot as especially the affection of servant-girls, often badly nourished, and obliged to be almost constantly on their feet. This class do not wear especially high heels; they do wear ill-fitting boots, with narrow soles, which compress and deform the toes, and rest their feet with cloth boots and slippers, which give no support to the arch; and in this class the tired feeling and dull ache in the feet, so characteristic of an over-strained arch, is very common.

Again, raising the heel in one of these cases does not increase the deformity. On the contrary, if the bare foot be placed squarely on the floor, and the body be inclined forward so that more weight is brought on the "waist" of the foot, it will be increased.

CONGENITAL OSSEUS MALFORMATION.

It has been suggested, because flat-foot occurs in robust persons, and because changes in the bone have been found, too great to be accounted for by mechanical causes, that an original osseous malformation

[6] Flat-Fcot, by M. P. Mayo-Collier. Lancet, September 4, 1886.

would best explain the origin of the affection.[7] The affection does, it is true, occur in robust persons, but if one of these patients be questioned, it will be found that he dates his symptoms from some strain or from some peculiarity in his occupation. As an illustration, a healthy, well-develped young man was sent to me last week, presenting a very considerable flattening of the arch of one foot, accompanied by pain, swelling, and muscular spasm. I found that his occupation as a bookbinder compelled him to stand all day on the affected foot, while he worked a treadle with the other. Again, I should not admit that the deformities of the bones, as described in the published autopsies, were too great for explanation on mechanical grounds. They are no greater than those found in other bones under similar conditions.

Lastly, the number of autopsies on flat-foot is too small to support any peculiar and improbable theory as a general explanation of the affection. It may be that these different theories have resulted from a failure to recognize the varying types of the affection. One observer sees cases or makes a dissection of a foot showing great relaxation of ligaments, and concludes that all cases result from lax ligaments. Another meeting acute cases where, as in acute affection of other joints, muscular spasm and contraction are prominent features, considers muscular spasm, contraction, atrophy or paralysis as exciting causes. While another accounts high heels responsible for the symptoms which he notices.

THE OVERWORK THEORY.

It seems to me that the most reasonable explanation of its cause is that of a disproportion between the weight the foot is called upon to bear and the ability of its muscles and ligaments to sustain it, a simple breaking down from overwork.

In lateral curvature of the spine, as in flat-foot, the

[7] Stokes. Annals of Surgery, Oct., 1885.

same theories of muscular spasm, contraction and atrophy have been advocated, also original deformities and primary changes in bones. As in lateral curvature, flat-foot is most common in adolescence, when changes in bones and soft parts are most rapidly taking place. The most reasonable explanation of the usual cause of lateral curvature, that is, overweight on a spine held out of the middle line[8] applies to the foot where overweight by exaggerating the normal movements already described, causes it to give way on its weakest side: its first effect being on the os calcis, causing its anterior extremity to turn inwards and downwards, at the same time depressing its internal border, thus presenting an inclined plane on which the astragalus rotates more decidedly inwards and slips downwards and inwards until in time, we have the appearance already mentioned, of outward displacement of the foot upon the leg.[9]

The natural weakness of the inner side of the foot may, in a certain class of cases, be increased, as follows: If von Meyer's tripod be drawn on the sole of a normal foot, that is, a triangle connecting the outer extremities of the first and fifth metatarsals with the middle of the heel, it will comprise within it the greater part of the weight-bearing surface of the foot, the weight-bearing centre of the astragalus falling within it, that is, outside the line connecting the first metatarsal with the heel. In certain cases, however, it does lie to the inner side, such cases being classed by Symington as having a mechanical tendency to valgus,[10] for in a normal foot the inner overhanging half of the astragalus is supported by the lateral projection of the os calcis, the sustentaculum tali, and if, as in these cases, it is so placed that its weight-bearing centre rests on this projection, it will readily be seen what an increased source of weakness this becomes,

[8] Bradford, Mass. Medical Society Reports, 1886.

[9] Vide The Mechanism of Flat-Foot, by Prof Humphrey, Lancet, March 20, 1886.

[10] The Anatomy of Acquired Flat-Foot, J. Symington, Journal of Anat. and Phys., Oct., 1884.

the weight of the body constantly tending to depress this support and evert the foot.

I have spoken of the overweight theory as the most reasonable general explanation of the affection. It will, of course, be understood that predisposing causes exist, either general, as rachitis, or special, as disease or injury of the ankle.

Flat-foot may be the direct result of violence, as in falling from a height, may be induced by a sprain, which may cause a permanent weakening of the ligaments, though a sprain is more likely to occur in a foot already weakened than to be of itself a cause of permanent trouble. Flat-foot as a result of cerebral or spinal paralysis need not be considered as an especial affection.

As to the weight-bearing surface of the fore-foot, its points that sustain the most weight have been variously stated, as, for example, the first metatarsal, the first and fifth metatarsals. Beely[11] concludes, from observation on plaster casts, that when the feet are in use the head of the second and third metatarsals bear the most weight; when standing on one foot the fifth assists.

I have found accurate estimation by plaster casts difficult, because the various muscles of the foot are so constantly acting, changing the weight-bearing surfaces to maintain the equilibrium; for example, if the body be inclined forwards the toes are instinctively pressed down, if backward they are raised. These changes are, of course, exaggerated, if the body be supported on one foot while the plaster is hardening.

In standing, the greater part of the weight is borne by the heels, the metatarsals acting rather to steady the foot than to bear weight. What weight they do bear seems to be proportionately distributed to them all. If, however, the weight is borne on one leg, the body being inclined forwards so that more weight is

[11] Archiv. für Klin. Chir., 1882, Bd. xxvii, p. 181.

brought on the front of the foot, it will be found that the three middle metatarsals rest quite steadily on the floor, while the first and fifth are constantly moving under the influence of their especial muscles to maintain equilibrium, the first bearing the greater part of the weight when the body is inclined inwards, the fifth when it is inclined outwards. The second and third are the weakest of the metatarsals, and are acted on by less muscular force than the others, so that the theory that they habitually sustain the most weight in standing seems improbable.

It will be remembered that the anterior part of the arch is formed almost exclusively by the three inner metatarsals, the two outer articulating with the cuboid bone practically resting on the floor when weight is borne.

This outer portion of the foot, firmly held to the os calcis by strong ligaments, forms with it one lever acted on by the tendons of the calf muscle. The three inner metatarsals being less under its influence, because it must act on them through yielding joints, while the first metatarsal depends for its flexion almost entirely on other muscles, principally the peroneus longus.

In walking, the weight of the body is first borne by the heel, then by the outer border of the foot; then follows a flattening, when all the metatarsals bear their share of weight; then the contraction of the peroneus longus and the tibialis posticus bring the strong first metatarsal down with force for a final impulse to the step, the foot being now slightly adducted. At the same time, the transverse pedis tends to bring the spread-out heads of the metatarsals together, while the flexors of the toes and the short muscles attached in this region contract to assist in the final impulse.

The free action of the toes and room for the spreading of the heads of the metatarsals is of great importance, and when one examines the shoes that are

worn, especially by women, and their effect upon the feet, the distorted and useless toes, with consequent corns and bunions, it seems extraordinary that the foot can perform its functions with so little discomfort. The normal angle of divergence of the foot from the line of the walk is about sixteen degrees ;[12] this turning out is principally dependent on the outward twist of the tibia, the weight line being thus brought over the second toe. In the valgus condition of abduction, this angle of divergence is increased by the inward displacement of the bones of the arch, so that the line of weight may fall inside the great toe, a constantly increasing strain thus falling on the waist of the foot. In this connection, it may be said that a person with bow-legs, whose weight falls principally on the outside of the foot, whose angle of divergence is small, or whose toes turn in from the inverse spiral twisting of the tibia which so often accompanies it, is practically assured against flat-foot, while the opposite condition of in-knee predisposes to it.

Whatever the cause of flat-foot may be, the result consists in a partial dislocation of the bones of the foot, with the usual accompaniments of a dislocation to a greater or less degree, overstretched and partially ruptured ligaments, misplaced tendons, changes in the cartilages and bones. The treatment, therefore, should be an endeavor to replace, partially, at least, the displaced bones, to retain them in this position, that the ligaments may regain their normal tonicity, and to increase the muscular power.

Gymnastic exercise faithfully and persistently followed will accomplish much, and a well-fitting appliance will usually relieve the symptoms, but a combination of these two agents will be productive of the best result.

The object of an appliance is to prevent the scaphoid, astragalus, and os calcis from sinking down, and

[12] Vierordt. Gehen des Menschen.

The importance of teaching a proper walk, both in the prevention and treatment of flat-foot, cannot be exaggerated; that the correct position of the feet is with the toes pointing straight ahead — a position which necessitates muscular activity — as distinct from the attitude of excessive divergence of the toes, which allows the walk of muscular inactivity and weakness shown in flat-foot.

the latter from rolling over. Anything that will prop up the arch will usually relieve the pain, and various means have been devised to this end. For example, pads of horsehair, India rubber or felt placed under the arch have been used. The objections to these are that it is difficult to keep them in place, and that they change their shape constantly, so that they only partially accomplish their purpose and are uncomfortable and often painful. A band of rubber, to which a pad is attached, sewed to the uppers inside the shoe, along the outer border of the sole, running beneath the sunken arch up the inside of the leg to a calf band,[13] or a band of webbing similarly arranged, attached by an elastic cord to the corset or waistband.[14]

The element of uncertainty in regulating the tension would here, also, be an objection. It seems to me that elastic pressure is not the thing required, for too great tension would be uncomfortable, while it would be difficult to so adjust it as to prevent the bones from sinking below their normal level.

Mr. Mayo-Collier, being convinced that high heels cause the deformity, advocates a shoe with a sole one inch in thickness at the toes, and a line at the heel; he does not state that he has employed it. I should doubt its efficacy, even in a mild case, and it must be so unsightly that few patients could be induced to use it.

Dr. Morton, of Philadelphia, advocates the use of a plantar spring with an inner flange, which, expanding under weight, will allow of the natural movements of the foot during walking or standing — an advantage which is claimed for the elastic bands which have been described. I think the necessity for such expansion of the support under weight has been exaggerated for the following reasons:

If an imprint of a normal foot which rests without weight upon the floor be compared with one of a foot

[13] W. J. Walsham. Lancet, January 26, 1884.
[14] F. King Green. Lancet, December 26, 1885.

supporting the entire weight of the body, it will be found in the latter that the free space showing the arch is considerably constricted on all sides. A considerable portion of this reduction is due to a pressing away of the soft parts from the bones, which rest with an increased weight on the base. If the arch be looked at from the side, it will appear diminished from this encroachment of the soft parts, especially by the belly of the abductor policis, which, when extended, shows its mass on the inside of the foot; but the actual fall of the head of the astragalus and the scaphoid is slight. If, however, a foot with a weakened arch be submitted to the same test, there is an actual falling of the bones, which may rest on the floor.

The state of things in a normal foot seems to be this: that when the foot rests easily on the floor without muscular tension, the bones fall to about their normal level under weight; that is, the ligaments are slightly extended.

Now, in standing, the ligaments are put on a tension, but their normal elasticity is slight, and at the same time the muscles come to their relief to prevent strain. When, however, the heel is raised or the foot lifted, there is a very considerable flexion at the mediotarsal joint, which is permitted because the dorsal ligaments are loose and weak. Thus, the natural movements of the foot would seem to consist in a very considerable flexion, but in very slight extension from the position which it assumes when resting easily on the floor.

In a flat-foot, however, we do, under weight, have the flattening and abduction which elastic bands and springs allow. These are not natural; they are abnormal movements, which should be prevented in order that the ligaments and muscles may regain their former tonicity. This restraint is especially desirable because, ordinarily, we cannot replace the bones of the sunken arch in exactly their former normal position, and often can do so only partially, even by the use of force.

Of the unyielding supports, there are two advo-

cated: first, the steel support, corresponding to the sole of the shoe, to which it is firmly attached; second, the long steel plate, reaching from the extremity of the heel to beyond the balls of the toes, with a flange to prevent the internal displacement of the foot. This latter appliance though much more efficacious than the former, is open to the objections of being rather heavy, and interfering to a certain extent with the normal flexion of the foot when walking, making it move as a whole, causing an awkward clumping gait. The apparatus which I should suggest seems to me to possess certain advantages. It is light, comfortable, provides pressure where it is required, and does not interfere with the movements of the foot. It can be changed from one shoe to another, and its presence cannot be detected. A plaster cast of the foot is taken, not as is ordinarily done, by pressing the sole in plaster, as this tends to increase the deformity, but the foot is first replaced in its normal position as far as possible by manipulation: the patient being seated, the cast is taken in lateral halves, the foot in each case lying upon its outer border on another chair, so that the weight of the leg tends to invert it while the plaster is hardening. If the foot is at a right angle, care must be taken to bring the ball of the great toe down to a level with the others, as the tibialis anticus drawing from its point of attachment at the internal cuneiform and base of the first metatarsal, tends to draw it up and lessen the concavity of the arch which we are endeavoring to deepen. The cast having been completed, the lines of the plate are drawn as follows: the point A is made beneath the ball of the great toe, just short of its bearing centre, a point, B, just short of the bearing centre of the heel bone, beneath its inner tuberosity,[15] C, just above the head of the astragalus, a little in front and below the internal malleolus. These three points are now connected by a gradually ascending line from A, rising above the

[15] The foot then rests upon its natural supports.

inner border of the foot, a little in front of the internal cuneiform bone, curving upward above the scaphoid, meeting at C, the line drawn upward from B. A curved line is drawn, three-quarters of an inch in length, whose centre corresponds to a point, D, on the outer aspect of the foot, just above and behind the tuberosity of the fifth metatarsal. The extremities of this line are now connected with A and B, and the shape of the plate is completed. (See Figures 3 and 4.) It should be made of thin-tempered steel accurately moulded on the cast. This plate presents the following peculiarities: It has the two bearing points, A and B; from them run the lever, D, leaving the balls of the toes free. This lever is caused by the slight flexion of the foot during the taking of the cast, for although in standing the entire outer border of the foot rests upon the floor, as may be seen in the imprint of a wet foot on paper, when it lies on its side, the medio-tarsal joint being flexed, this outer border is slightly raised, an interval of from one-third to one-half an inch intervening between it and a line

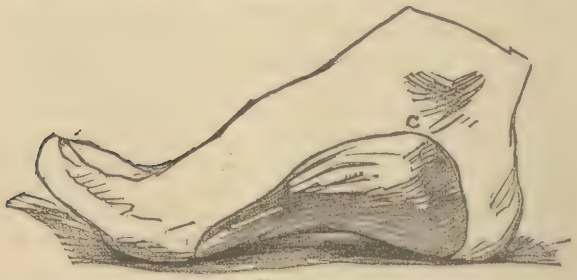


FIG. 3.
Drawn from a cast of a corrected flat-foot, showing plate in position.

drawn from the heel to the head of the first metatarsal. The plate being fitted to the cast in this position, it results that the foot in standing and walking will press this external arm solidly against the sole of the shoe; consequently, the tendency will be to press the

The outer third of the arm D should be perfectly flat, so that this portion of the foot may lie easily against the sole of the shoe when weight is borne.

internal flange more firmly against the weak portion of the foot, and upward and outward beneath the sustentaculum-tali and the tuberosity of the scaphoid, at the moment when the tendency of the foot is to slide away from it. This pressure during the step has a tendency to throw the weight more on the outside of the foot, and to turn the toes in, resisting the exaggerated abduction. This tendency the patient should voluntarily assist, trying to reduce the angle of divergence, thus relieving the inside of the foot of a portion of the strain by bringing the line of weight back to its normal position.

FIG. 4.

Well-fitting, laced boots of the Waukenphast pattern, or with an even greater inward twist, with broad soles and low heels, should be worn. In some cases the weak ankle may be favored by raising the inner side of the heel and sole with a strip of leather. It should not, however, be carried beyond a point just behind the ball of the great toe, and may often with advantage be limited to the heel. It might be supposed that the pressure of the plate against the prominent scaphoid would cause pain, but this does not seem to be the case. The scaphoid does not rotate inwards, as does the astragalus, and, being held up by the plate, it does not greatly change its position. It is sometimes so prominent in the cast that a depression is found in the plate to accommodate it.

The statement that a firm support under the arch is painful, because it will press on inflamed and sensitive

tissues, or that it will press the internal plantar nerve against the astragalus is disproved by practice.[16] If the extremities of the bones are sensitive and inflamed it is because they are out of place. If they can be even partially replaced the inflammation speedily disappears. In this connection I may mention one case, that of a robust young man who had been obliged to give up various positions on account of his feet, becoming finally almost entirely disabled. Two weeks after plates were fitted to him he obtained a position as porter in a hotel, where he has ever since carried trunks up and down stairs without pain or discomfort. It will, of course, be understood that if an overstrained arch be seen before permanent change has taken place it might, by rest, and a removal of the cause which produced it, be entirely relieved without the aid of an apparatus, but, unfortunately, in the class most subject to this affection daily labor is a necessity.

In an acute case, accompanied by pain, redness and swelling, the foot should be placed for a few days in a plaster bandage in an adducted and inverted position; afterwards rubbing and bandaging will bring it into condition for the plate. In old cases a forcible breaking up of adhesions and reposition under ether is sometimes necessary, I have not as yet seen a case where an operation seemed advisable, because I have found that the plate relieves the symptoms, and one would hardly be justified in operating solely on account of the deformity. The condition of the joints in old cases is not favorable to cure by operation, and if such laxity of ligaments existed as in an autopsy reported by Symington, where a finger could be placed between the astragalus and tibia, an ankylosis of the astragalus and scaphoid would scarcely relieve the deformity or symptoms.

It is evident that the hope of permanent cure must

[16] This statement has been made in regard to the various pads that have been used. The superiority over these of a smooth, accurately-fitting steel support, with its equalized pressure, must, I think, be apparent to all.

depend upon an increase of muscular power, the age of the patient, and the amount of permanent change in the foot being taken into consideration.[17] The

FIG. 5.
From a photograph by Dr. R. A. Kingman.

muscles which support the arch are principally those which run beneath the inner malleolus, the most important being the tibialis-posticus. The flexor longus

[17] Mr. Roth who formerly used pads of felt beneath the sunken arch, now depends entirely upon muscular exercise for the cure of flat-foot (New York Medical Record, March 17, 1888). Figure 5 is a typical illustration of the more advanced cases,— A barber, who, standing all day by his chair, "has endured misery for fourteen years." In such a case of what use are minutes of exercise, to be followed by hours of overwork for the weakened unsupported foot?

policis from the position of its tendon, which runs in a groove on the posterior internal corner of the astragalus, and beneath the sustentaculum tali is of especial service in resisting the movements of the foot under weight. The calf muscle, which adducts as well as extends the foot, the tibialis anticus, which braces the arch, and the peroneus longus, which deepens it, should also be mentioned. As to gymnastics, the exercises recommended by Mr. Ellis can scarcely be improved upon.[18] They are as follows:

"The patient when sitting, or better when lying down, should be directed to forcibly invert the foot, and flex the toes as much and as often as can be done; should learn as soon as possible to spring on tip-toe, sustaining the position a while, and then gradually sinking on to the heel; and in standing should bear part of the weight on the toes. The best exercise is to raise a weight by a cord running over a pulley, as one must grip the floor with the toes when pulling the weight down; or he may turn a wheel whose handle is too high for the body. The patient should walk with a springy gait. The toes should reach the ground a moment before the heel. This can only be done properly in boots without heels."

I should add that prolonged soaking in hot water, followed by massage with manual flexion and inversion of the foot is often of service.

In conclusion, it may be said that some judgment is required in taking the cast for the pattern. In chronic cases the arch may be made as deep as possible: when, however, the foot can be easily replaced, care should be taken not to flex it too much, as the plate may cause painful pressure. It, fortunately, is most efficacious in the painful and disabling cases, where usually the deformity is not extreme. In cases where there is great laxity of ligaments, and outward displacement of the foot, an ankle support may, in addition, be necessary.

[18] T. S. Ellis. Lancet, Sept. 26, 1885.
See also Roth, loc. cit.